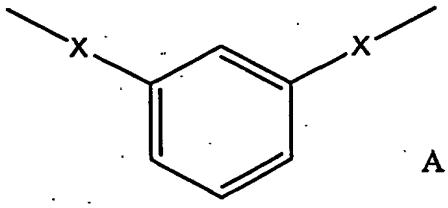
Claims

1. A polymer electrolyte membrane or gas diffusion electrode which includes an ion-conducting polymeric material which includes moieties of formula



A

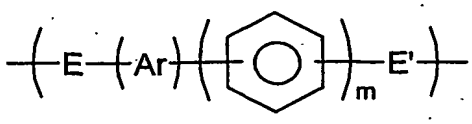
which are substituted on average with more than 1 and 3 or less groups (e.g. sulphonate groups) which provide ion-exchange sites and hydrogen atoms of said moieties are optionally substituted, wherein each X in said moieties of formula A independently represent an oxygen or sulphur atom.

2. A membrane or an electrode according to claim 1, wherein said moieties are substituted on average with 1.8 to 2.2 of said groups which provide ion-exchange sites.

3. A membrane or an electrode according to claim 1 or claim 2, wherein said ion conducting polymeric material is of a type which includes:

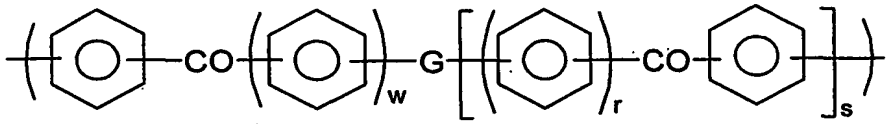
(i) phenyl moieties;
(ii) carbonyl and/or sulphone moieties; and
(iii) ether and/or thioether moieties.

4. A membrane or an electrode according to any preceding claim, wherein said ion conducting polymeric material includes a moiety of formula



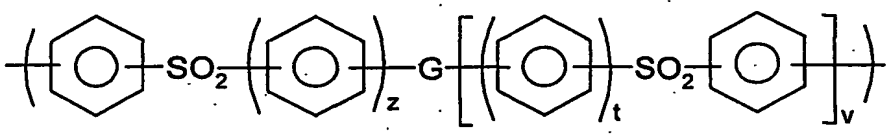
I

and/or a moiety of formula



II

and/or a moiety of formula

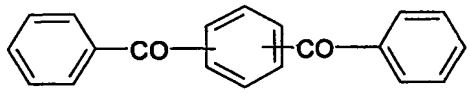


III

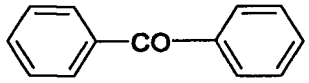
wherein at least some of the units I, II and/or III are functionalised to provide ion-exchange sites, wherein unit A is a part of units I, II and/or III, wherein the phenyl moieties in units I, II, and III are independently optionally substituted and optionally cross-linked; and wherein m,r,s,t,v,w and z independently represent zero or a positive integer, E and E' independently represent an

oxygen or a sulphur atom or a direct link, G represents an oxygen or sulphur atom, a direct link or a -O-Ph-O- moiety where Ph represents a phenyl group and Ar is selected from one of the following moieties (i)* or (i) to (x) which is bonded via one or more of its phenyl moieties to adjacent moieties

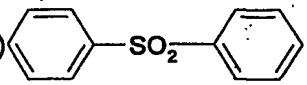
(i)*



(i)



(ii)



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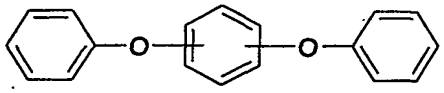
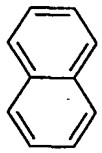
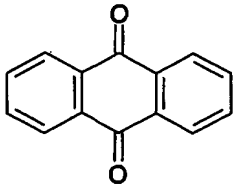


(iv)

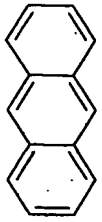
(v)



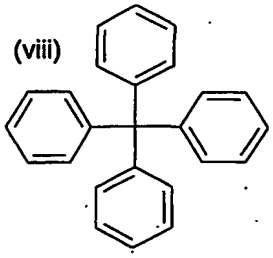
(vi)



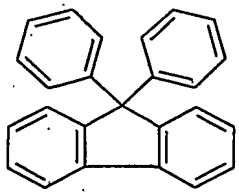
(vii)



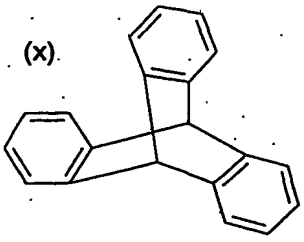
(viii)



(ix)



(x)



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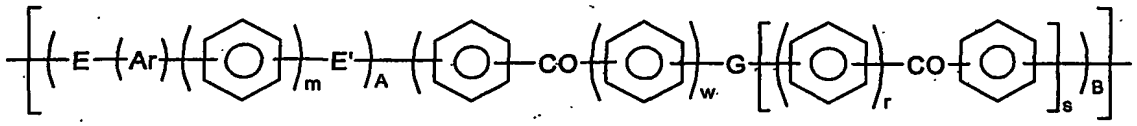
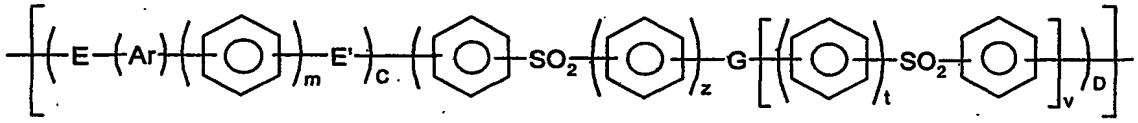
5. A membrane or an electrode according to any preceding claim, wherein said ion-conducting polymeric material is sulphonated.

6. A membrane or an electrode according to any preceding claim, wherein said polymeric material is a homopolymer having a repeat unit of general formula

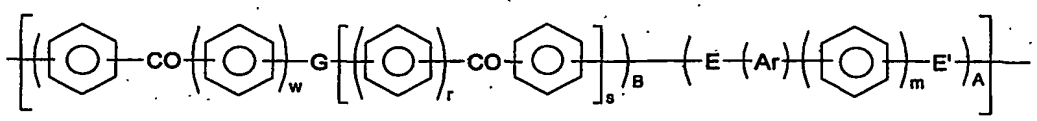


or a homopolymer having a repeat unit of general formula



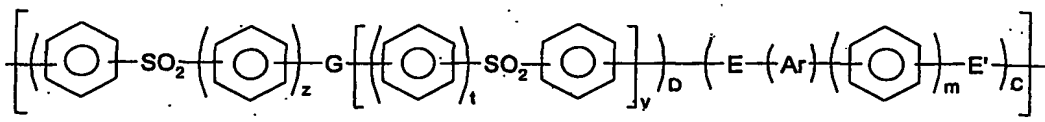
or a random or block copolymer of at least two different units of IV and/or V provided that repeat units (or parts of repeat unit) are functionalised to provide ion-exchange sites;

or a homopolymer having a repeat unit of general formula



IV*

or a homopolymer having a repeat unit of general formula



V*

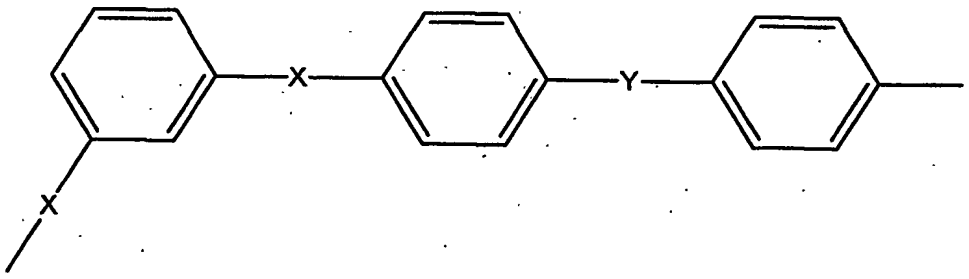
or a random or block copolymer of at least two different units of IV* and/or V* provided that one or more repeat units (or parts of repeat units) are functionalised to provide ion-exchange sites;

wherein A, B, C, and D independently represent 0 or 1 and E, E', G, Ar, m, r, s, t, v, w and z are as described in claim 4.

7. A membrane or an electrode according to any preceding claim, wherein said ion-conducting polymeric material is crystalline or crystallisable.

8. A membrane or an electrode according to any preceding claim, wherein said polymeric material includes at least some ketone moieties in the polymeric chain.

9. A membrane or an electrode according to any preceding claim, wherein said ion-conducting polymeric material includes a repeat unit of formula



B

wherein the 1,3- substituted -X-Phenyl-X- moiety is substituted on average with more than 1 and 3 or fewer groups which provide ion-exchange sites, each X independently represents an oxygen or sulphur atom and Y represents a carbonyl or sulphone group.

10. A membrane or an electrode according to claim 9, wherein Y represents a carbonyl group and X represents an oxygen atom.

11. A membrane or an electrode according to any preceding claim, wherein any -O-phenyl-CO or -O-phenyl-SO_2 moieties in said ion-conducting polymeric material are functionalised with ion-exchange sites to a level of less than 10 mole%.

12. A membrane or an electrode according to any preceding claim, wherein the only moieties in said ion-conducting polymeric material which are functionalised with ion exchange sites are moieties A.

13. A membrane or an electrode according to any preceding claim, wherein substantially 100 mole% of moieties A are difunctionalised.

14. A membrane or an electrode according to any preceding claim, wherein said ion conducting polymeric material is a copolymer comprising a first repeat unit which is selected from the following:

(a) a unit of formula IV wherein E and E′ represent oxygen atoms, G represents a direct link, Ar represents a moiety of structure (iv), m and s represent zero, w represents 1 and A and B represent 1 provided that said unit includes moiety A, with both X atoms being oxygen atoms;

(b) a unit of formula V wherein E and E' represent oxygen atoms, G represents a direct link, Ar represents a moiety of structure (v), m and s represent zero, w represents 1 and A and B represent 1 provided that said unit includes moiety A, with both X atoms being oxygen atoms;

and a second repeat unit selected from one of the following:

(c) a unit of formula IV wherein E and E' represent oxygen atoms, G represents a direct link, Ar represents a moiety of structure (iv), m and s represent zero, w represents 1 and A and B represent 1;

(d) a unit of formula IV wherein E represents an oxygen atom, E' represents a direct link, Ar represents a moiety of structure (i), m represents zero, A represents 1, B represents zero;

(e) a unit of formula V wherein E and E' represent oxygen atoms, G represents a direct link, Ar represents a moiety of structure (iv), m and v represent zero, z represents 1 and C and D represent 1;

(f) a unit of formula V wherein E represents an oxygen atom, E' represents a direct link, Ar represents a moiety of structure (ii), m represents 0, C represents 1, D represents 0;

(g) a unit of formula V wherein E and E' represents an oxygen atom, Ar represents a structure (i), m represents 0, C represents 1, Z represents 1, G represents a direct link, v represents 0 and D represents 1;

(h) a unit of formula IV wherein E and E' represent oxygen atoms, G represents a direct link, Ar represents a moiety of structure (iv), m represents 1, w represents 1, s represents zero, A and B represent 1;

(i) a unit of formula IV wherein E represents an oxygen atom, E' is a direct link, G represents a direct link, Ar represents a moiety of structure (iv), m and s represent zero, w represent 1, A and B represent 1;

(j) a unit of formula V wherein E and E' represent oxygen atoms, G represents a direct link, Ar represents a moiety of structure (iv), m represents 1, z represents 1, v represents 0, C and D represent 1;

(k) a unit of formula V wherein E represents an oxygen atom, E' represents a direct link, G represents a direct link, Ar represents a moiety of structure (iv), m and v represent zero, z represents 1, C and D represent 1;

(l) a unit of formula IV wherein E and E' represent oxygen atoms, G represents a direct link, Ar represents a moiety of structure (v), m represents 0, w represents 1, s represents 0, A and B represents 1;

(m) a unit of formula V wherein E and E' represent oxygen atoms, G represents a direct link, Ar represents a moiety of structure (v), m represents 0, z represents 1, v represents 0, C and D represent 1.

15. A membrane or an electrode according to claim 14, wherein said ion-conducting polymeric material includes a

first unit selected from (a) or (b) in combination with a second unit selected from (d) or (f) optionally in combination with unit (g).

16. A membrane or an electrode according to claim 14, wherein said ion-conducting polymeric material comprises unit (a) in combination with unit (d); unit (a) in combination with units (d) and (g); unit (b) in combination with unit (f); and unit (b) in combination with units (f) and (g).

17. A membrane or an electrode according to any preceding claim, wherein said polymer electrolyte membrane has an equivalent weight (EW) of less than 500g/mol.

18. A fuel cell or electrolyser incorporating a polymer electrolyte membrane according to any of claims 1 to 17.

19. An ion conducting polymeric material as described in any of claims 1 to 17 per se.

20. A method of making a sulphonated ion-conducting polymeric material as described in any preceding claim, the method comprising contacting a polymeric material which includes a repeat unit of formula A according to claim 1 with a sulphonating agent thereby to substitute the repeat unit on average with more than 1 and 3 or fewer sulphonate groups.

21. A method according to claim 20, wherein said conditions for controllably sulphonating the polymeric material involve the use of sulphuric acid at a concentration of at least 99.5%.

22. A method according to claim 21, wherein the sulphuric acid concentration is less than 100.1%.

23. A method according to claim 21 or claim 22, wherein the temperature during sulphonation is 30°C or above.

24. A method according to any of claims 20 to 23, wherein the temperature during said sulphonation is 40°C or less.

25. A method according to claim 23 or claim 24, wherein the selected temperature or temperature range is maintained for at least 2 hours and for less than 20 hours.

26. A method according to any of claims 20 to 25, which is carried out by use of 99.8% to 100% sulphuric acid at 34 to 36°C.